APPLICATION

FOR

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TITLE: HIGH CAPACITY BACKBONE

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High Capacity Backbone

TECHNICAL FIELD

This invention relates to communication systems.

BACKGROUND

In a long-distance carrier's backbone network, the network nodes are telephone sets that typically have only the most rudimentary processing capabilities. As a result, error correction or data protection in the telephone network, if it is to exist at all, is provided by the network, and not by telephone sets.

In a telephone network that includes optical fibers, commercially available SONET ("Synchronized Optical Network") infrastructure bears the brunt of error detection and correction for data on a working fiber. This enables the telephone sets to remain free of processing equipment. In such networks, a diversely routed protection fiber provides the basis for data protection should the working fiber of the SONET network be severed.

In recent years, internet traffic has begun sharing the telephone network with non-internet traffic such as that resulting from telephone calls, ATM cells, frame relay, and private line services. To achieve network transparency, internet traffic is treated like conventional telephone traffic. Consequently, routers and other internet-traffic sources that connect to optical fibers typically do so through SONET interfaces. These interfaces embed the TCP/IP packets (hereafter referred to as "data packets") sent by internet-traffic sources into SONET frames, thereby allowing those data packets to be processed in the same manner as conventional telephone traffic.

Because data packets are placed in SONET frames, each internet-traffic source and destination (referred to collectively as "internet nodes") in the network must have access to a SONET interface. These SONET interfaces and the infrastructure that supports them add considerable cost and operational complexity to a network.

The overhead associated with SONET networks is justifiable in the case of telephone traffic because no error protection would otherwise exist. However, in the case of internet traffic,

there is no longer a basis for justifying this overhead. In comparison to telephone sets, internet-traffic sources and destinations have considerable processing capability. Headers in TCP/IP data packets already carry information that enables routers to perform error correction. Further, TCP/IP protocols are, by design, highly resilient to adverse network conditions. As a result, internet nodes need not depend on a SONET network for protection against disruptions in the network. Consequently, there is little, if any, additional benefit to justify the added cost associated with providing dedicated protection fibers.

SUMMARY

A communication system according to the invention eliminates the SONET infrastructure between the internet-traffic sources and destinations and the optical fiber. This enables internet traffic to be carried directly on the fiber in its native form, without intermediate SONET multiplexing equipment. By eliminating the need for such equipment, a communication system incorporating the invention eliminates the overhead associated with providing all internet-traffic sources and destinations with access to SONET interfaces. In addition, the communication system also liberates bandwidth that would otherwise be consumed by the SONET network. When internet traffic is carried on the fiber in its native form, the protection fiber need not wait for a disruption in the working fiber before it can be of use. Instead, the protection fiber can immediately be used to carry additional data packets, thereby effectively doubling the bandwidth of the network. Any data protection associated with the internet traffic is provided by the protocol itself, and not by the maintenance of a protection fiber in addition to a working fiber.

The communication system includes an optical transmission network having an input end and an output end. The optical transmission network can be of any type. However, because of anticipated growth in internet traffic, one embodiment of the invention includes an OC-192 capable optical transmission network.

A wavelength division multiplexer coupled to the input end of the optical transmission network receives data packets directly from each internet-traffic source and modulates, in response to those data packets, a corresponding optical beam having a selected wavelength. At the other end of the optical transmission network, a wavelength division demultiplexer is

configured to select a particular optical beam corresponding to each internet-traffic source and to retrieve the data packets placed thereon by the wavelength division multiplexer.

In one aspect of the invention, the wavelength division multiplexer includes a plurality of wavelength translators, each being directly connected to an internet-traffic source. The wavelength translators are configured to generate a beam having a selected wavelength and to modulate that beam in response to data packets received from the internet-traffic source. The wavelength translators are all coupled to an optical coupler that combines the beams generated by each wavelength translator and places the superposition of those beams onto the optical transmission network.

In another aspect of the invention, a plurality of wavelength translators is coupled to the output end of the optical transmission network. Each of the wavelength translators is connected to an internet-traffic destination. These wavelength translators are configured to receive data packets from the demultiplexer and to provide those data packets to the internet-traffic destination.

An alternative embodiment of the communication system shares available bandwidth with SONET traffic. In this embodiment, the communication system includes a first SONET interface coupled to the input end of the optical transmission network. This first SONET interface is configured to receive data from a SONET-traffic source for transmission on the optical transmission network. These SONET frames are transmitted on a selected wavelength dedicated to SONET traffic. As a result, their presence does not impact internet traffic carried as data packets on other wavelengths.

The alternative embodiment can also include a second SONET interface coupled to the output end of the optical transmission network. The second SONET interface is configured to retrieve the SONET frame from the optical transmission network and to provide the data contained therein to a SONET-traffic destination.

A communication system according to the invention thus enables internet traffic from many sources to be carried directly on an optical transmission network. This reduces cost by eliminating expensive SONET interfaces at each internet-traffic source and at each internet-

traffic destination. The communication system can nevertheless continue to accommodate SONET traffic by placing the SONET traffic onto wavelengths dedicated to such traffic.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

These and other features of the invention will be apparent from the following detailed description, and the accompanying figures in which:

DESCRIPTION OF DRAWINGS

FIGS. 1 and 2 are communication systems according to the invention.

DETAILED DESCRIPTION

FIG. 1 shows a communication system **10** connected to several internet-traffic sources **12a-n**, each of which generates an source beam **14a-n** at source wavelengths λ_1', λ_2'... λ_n'. The source wavelength is tuned to a value specific to the type of router. Where the internet-traffic source is a typical router, source wavelengths are generally either 1310 nanometers or 1550 nanometers. The source beam **14a-n** of each internet-traffic source **12a-n** is modulated in accordance with the data that the corresponding router **12a-n** is to send over the communication system **10**.

The source beams **14a-n** of the internet-traffic sources **12a-n** are provided as inputs to corresponding wavelength translators **16a-n**. Each wavelength translator **16a-n** generates a transmission beam **18a-n** at a transmission wavelength λ_1, λ_2... λ_n. These transmission wavelengths are typically in the C band between 1530 and 1565 nanometers or in the L band between 1565 and 1620 nanometers. The transmission beams **18a-n** from each of the wavelength translators **18a-n** are provided to a first optical coupler **20**.

The first optical coupler **20** combines the transmission beams **18a-n** from all internet-traffic sources **12a-n** and places those beams on an optical fiber **22**. A communication system **10** according to the invention can incorporate any type of optical fiber **22**. However, because of the

anticipated growth in internet traffic, it is preferable that optical fibers capable of transmission at OC-192 or higher be used in implementing the communication system **10**.

The wave propagating on the optical fiber **22** is thus the superposition of the transmission beams **18a-n** associated with each of the internet-traffic sources **12a-n**. In this way, the wavelength translators **16a-n** and the first optical coupler **20** cooperate to function as a wavelength division multiplexer.

In a typical ultra-long haul fiber-optic network, distances are sufficiently long so that the amplitude of the propagating wave decreases significantly. To remedy this, amplifiers **24** are placed on the optical fiber **22** at intervals of approximately 60 miles.

In an optical fiber **22**, different frequency components of a signal propagate at different speeds. This results in dispersion: the broadening and distortion of pulses as they propagate along the optical fiber **22**. To correct for the effect of dispersion, it is useful to provide regenerators **26** at intervals along the optical fiber **22**. Such regenerators **26** can be optical-electronic-optical devices. Alternatively, such regenerators **26** can be all-optical devices, such as selected lengths of negative-dispersion fiber. However, the use of all-optical regenerators will enhance the overall efficiency of the communication system **10**.

The optical fiber **22** terminates in a second optical coupler **28** that distributes the superposition of beams to each of a plurality of demultiplexers **30a-n**. Each demultiplexer **30a-n** selects one of the transmission wavelengths λ_1, λ_2... λ_n and provides the beam having that wavelength to an internet-traffic destination **36a-n**.

In some cases, an internet-traffic destination **36a-m** may not be capable of receiving the selected transmission wavelength directly. In these cases, the corresponding demultiplexers **30a-m** provides the beams having the selected transmission wavelengths to wavelength translators **32a-m** associated with those demultiplexers **30a-m**. The wavelength translators **32a-m** generate corresponding destination beams **34a-m** at destination wavelengths λ_1'', λ_2''... λ_m''. The destination beams **34a-m** are then provided to internet-traffic destinations **36a-m** connected to the corresponding wavelength translators **32a-m**.

In other cases, an internet-traffic destination **36n** is capable of receiving the selected transmission wavelength directly. In these cases, the corresponding demultiplexer **30n** provides the beam having that wavelength directly to the internet-traffic destination **36n**.

In another embodiment, shown in FIG. 2, the optical fiber **22** carries both internet traffic and SONET traffic. This embodiment is identical to that discussed above in connection with FIG. 1 except for the addition of a source SONET interface **38** connected between a SONET-traffic source **40** and the first optical coupler **20** and a destination SONET interface **42** connected between a SONET-traffic destination **44** and the second optical coupler **28**. Because SONET traffic is assigned to its own wavelength on the optical fiber **22**, the internet traffic on the remaining wavelengths is unaffected by the presence of SONET traffic. The communication system **10** thus enables the sharing of the same optical fiber **22** between SONET traffic and internet traffic. SONET traffic can exist between nodes having limited processing capability, and therefore requiring the benefits of SONET. Internet traffic can exist between nodes having significant processing capability, for which the benefits of SONET are, to a great extent, redundant.

It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims.

Having described the invention, and a preferred embodiment thereof, what we claim as new, and secured by letters patent is: